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The Effects of Using Micro Steel Fibre Towards Compressive Strength on Concrete Mix Design

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Abstract: Micro Steel fiber (MSF) concrete is one of the special concretes that normal concrete mix with discontinuous discrete steel fiber. The concrete will face several failures and considered as non-sustainable in the long term and need extra costs for maintenance and reconstruction. The study attempted to investigate the effect of using Micro Steel Fiber towards density and compressive strength development in concrete mix design. A widespread experimentation was performed to study the strength development of concrete containing Micro Steel Fibers. In present investigation series of cubes were casted with different percentage of volume of Micro Steel Fiber. Micro Steel Fiber are used at 0.5%, 0.75%, 1%, and 1.25%. Compression test were conducted on samples to measure the effect of Micro Steel Fiber on compressive strength of concrete. Samples were cure for 7 and 28 days before tested the strength using compression machine in Concrete Laboratory, UTHM Campus Pagoh. Data analysis was performed to determine how well Micro Steel Fiber concrete performs in terms of density and compressive strength. The highest result for compressive strength is 64.22 MPa produced by sample containing 1.25% of MSF. In the same way, the highest density also produced by the sample 1.25% of MSF at 28 days of curing period. In conclusion, the objective of this study are successfully achieved where adding Micro Steel Fiber in concrete sample increased the density and compressive strength development.

Keywords: Concrete, Micro Steel Fiber, Workability, Density, Compressive

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1. Introduction

Steel fiber concrete is one of the special concretes that normal concrete mix with discontinuous discrete steel fiber. The evolution of using steel fibers in the field is to replace and reduce the traditional reinforcement bar in the concrete members. Thus, steel fiber tent to increase the tensile strength of the concrete by deflecting micro cracks which develop in the concrete under exterior force and load effects. As an important building material, concrete has been widely used in civil engineering applications such as bridges and roads engineering, and the related experimental study the effects of using micro steel fiber towards compressive strength on concrete mix design [1]. Furthermore, concrete structure does indeed have a weak tensile strength, lack of flexibility, and moderate fracture toughness. This inherently due to micro cracks and lead to brittle fracture of the concrete. Moreover, the addition of Micro Steel Fiber (MSF) can closely space, this would act as crack arrester and increased the strength of the concrete.

High-performance concretes, such as fiber-reinforced concrete, were gradually implemented in significant structural components as the engineering manufacturing sector developed. [2]. However, the analysis revealed that the strengthening effect of mechanical properties will be influenced by the uneven aggregation of steel fibers, thus affecting the smoothness and uniformity of concrete mixing. According to previous research, the maximum strength of concrete is obtained by addition the steel fiber compared to the used of glass and polypropylene [3]. In the same way, by applied steel fiber into the concrete mixed in specific percentage, the mechanical properties, toughness and workability of the structure have also strengthened [4].

This research was conducted to investigate the effectiveness of using Micro Steel Fiber towards density and compressive strength in the concrete. This can be such an alternative way to resolve the proposition and as the function of additive materials. It also can be used as a way to repair the performance of concrete. Moreover, the implement of Micro Steel Fiber is poorly implemented and applied in sector of construction and manufacturing inductrynowadays. The aim of this study is to determine the effect of Micro Steel Fiber towards density and compressive strength development in concrete and to study the workability of concrete containing Micro Steel Fiber.

2. Materials and Methods

Generally in this research, the Micro steel Fiber Micro steel Fiber has been utilized to assess the practicality of using it as a partial replacement additive for ordinary Portland cement (OPC) in order to reduce the amount of cement used. The main materials used in this study is fine and coarse aggregate, ordinary Portland cement, Micro Steel Fiber and water. The fine and coarse aggregate, portland cement used in this study is taken from concrete laboratory in UTHM Pagoh. The materials used in this study was not involved any additional processing compare to other binders.

The mix design of concrete was calculated according to British Standard Method of concrete mix design (DOE). The concrete mixed was designed to achieve 30 N/mm^2 at 28 days of curing. In this study, the samples have been casted in a cubic mold with the size of 100mm x 100mm x 100mm. This method was according to BS EN 12390-1:2012.

2.1 Workability

The workability test were conducted to study concrete that containing Micro Steel Fiber. There are two methods used to determine the workability which are slump test and compacting factor test. The factor that effect the workability of concrete are water cement ratio, aggregate, admixture, finest of cement, time and temperature.

2.2 Density Test

The density test were conducted to determined the effects of MSF in the concrete. To determine the density of concrete sample, the unit weight was determined using equation 1. The weight of the sample were measure and devide by its volume.

$$\text{Density} = \text{Average Weight of Samples (kg)} \div \text{Volume of Sample (m}^3\text{)} \quad \textbf{Eq. 1}$$

2.3 Compressive Strength Test

This method according to standard BS EN 12390-3:2019. The 'concrete cube test' is the most familiar test and is used for quality control purposes as the traditional form of calculating compressive power [6]. There were be a minimum of three samples tested at each selected age. The crushing strength of concrete was given by an average of three sample. The strength requirements of concrete.

Firstly, the sample were taken out from the curing tank and the surface of the sample is wiped out to remove the water. Then, the dimensions of the sample were measured and the values are recorded. Next, the sample were place appropriately in the test machine. Next, the yield strength to the face horizontal to the casting direction has been reported. Then, the sample were positioned centrally in the machine's base plate. After that, the compression machine is ensured to touch the top and bottom surface of the sample and then, gradually increased the load approximately 140 kg/cm2/minute until the failure occurred. Lastly, the compressive strength was measured [5].

3. Results and Discussion

This analysis was performed to determine how well Micro Steel Fiber concrete performs in terms of density and compressive strength. Compressive strength for Micro Steel Fiber concrete was adequate for higher density mixtures. The density increased due to the increase of Micro Steel Fiber throughout the samples of concrete. As a result, as the Micro Steel Fiber percentage increases, compressive strength increases. Concrete which is more density has even more strength and less fractures and impurities than concrete which is less density. Water and soluble substances were even less permeability to concrete with less cracks. As a result, water absorption will be reduced, and this form of concrete should last longer.

3.1 Workability of Concrete

Workability is a characteristic in the process of placement and finishing that has a direct impact on strength, quality, aesthetics, and even production costs. Table 1 shows the result of slump test and the percentage different compared to control sample.

According to **Table 1** the result for slump test were significantly decreased when the Micro Steel Fiber percentage increased. The higher slump test is 84 mm which is the controlled sample. The lowest slump test value is produced by sample 1.25% MSF which is 64 mm. The difference between these two samples were approximately 24 %. This significant different because when the Micro Steel Fiber added to the sample, the workability reduced. However, all the samples used in this study have meet the requirement for concrete mix which is in the range of 50 to 100 mm (75±25mm).

Figure 1 shows the result of slump test for all samples. According to the **Figure 1**, all the sample used in this study has meet the range of slump test. The data for the sample is 84mm which is the height of slump value. The slump value decrease in the following sequence which 79 mm for sample concrete 2, 75 mm for sample concrete 3, 69 mm for sample concrete 4 and 64 mm for sample concrete 5. This graph shows that, the slump achieved the range of true slump test according to BS EN 12350-2:2009.

Table 1: Slump test and the percentage different compared to control sample

Sample mixed	MSF Volume Faction (%)	Workability of Concrete	
		Slump (mm)	Percentage different compared to control sample (%)
Controlled	0	84	-
0.50% MSF	0.50	79	5.95
0.75% MSF	0.75	75	10.71
1.00% MSF	1.00	69	17.86
1.25% MSF	1.25	64	23.81

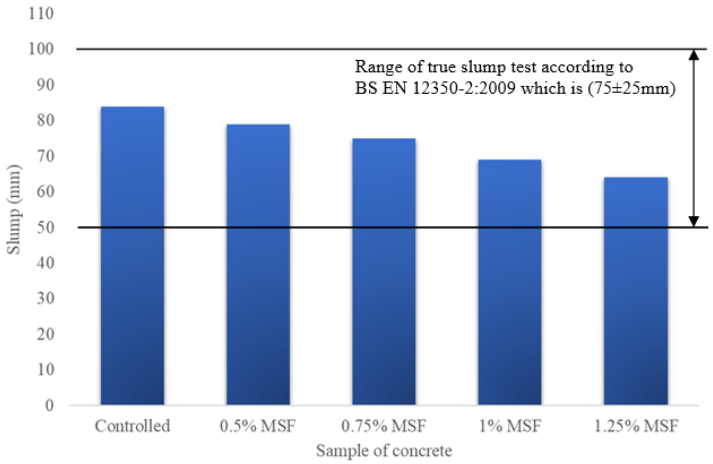

Figure 1 Workability: result of slump test for all samples

3.2 Density of concrete

Density is a measure of a specific material per unit volume which is calculated using the formula d = M/V, where d is density, M is mass and V is volume. The density of a substance is usually measured in grams per cubic centimeter. **Table 2** shows the density of the samples curing for 7 days and 28 days. It can be clearly seen from the result that the density of the concrete increased along with the increased in Micro Steel Fiber content. Maximum density value is produced by 1.25% MSF which is 24.23 N/m3 at 28 days of curing. Meanwhile, the minimum density value is produced by controlled sample which is 23.40 N/m3. The **Table 2** also shows that when Micro Steel Fiber is added, the density increased. This is because the Micro Steel Fiber has successfully filled the empty void in the concrete sample. Apart from that, the table 2 also shows the increment of density value along with the curing period. For example, sample 0.75% MSF produced 23.67 N/m3 at day 7 and increase to 23.87 N/m3 at day 28. These shows that the curing period is also give the effect towards density development of concrete samples. Additionally, these significant results have obtained because the concrete sample has reached its true strength.

Table 2: Density of the Concrete

Sample mixed	MSF Volume Faction (%)	Density of Concrete (N/m^3)		Differential in Percentage (%)
		7days	28 days	
Controlled	0	23.17	23.40	23
0.50% MSF	0.50	23.35	23.70	33
0.75% MSF	0.75	23.67	23.87	20
1.00% MSF	1.00	23.90	24.10	20
1.25% MSF	1.25	23.97	24.23	26

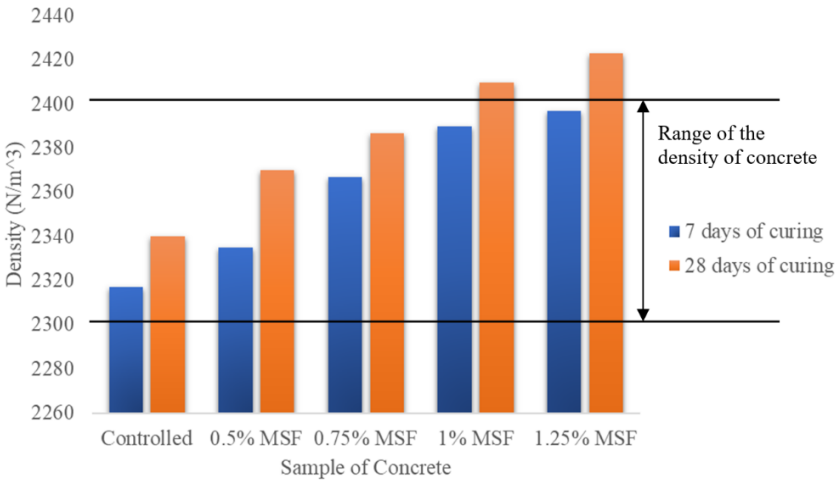

Figure 2 Density vs Sample of Concrete

Figure 2 shows the density of the concrete with different mix ratio. As shown in **Figure 2**, it is clear that the sample containing 1.25% Micro Steel Fiber produced the highest density among all samples with 2423 kg/m^3 at 28 days of curing. Although this value is highest if compared to the control sample, it does not mean that this percentage is the best because according to the previous researches, the density of normal concrete cube sample is in the range of 2300 kg/m^3 to 2400 kg/m^3. Apart from that, lower percentage of Micro Steel Fiber used in sample provide the better density value which is 2370 kg/m^3 and 2387 kg/m^3 for sample containing 0.5% MSF and 0.75% MSF respectively. The **Figure 2** also shows that the density value for 28 days increased compared to the sample cured for 7 days. This clearly shows that the density is influenced by the number of curing days and it can be concluded that 28 days of curing is the most significant to measure the density.

3.3 Compressive strength of concrete

The most common test on hardened concrete is the compressive strength test, and compressive strength is the most essential parameter in building structure. Table 3 shows the average compressive strength and the different percentage of curing days.

According to **Table 3**, the value of compressive strength shows an increasing trend of compressive strength with the additional of Micro Steel Fiber. The highest compressive strength is achieved by a sample containing 1.25% of Micro Steel Fiber with 52.81 MPa and 62.22 MPa for 7 and 28 days of curing, respectively. The lowest compressive strength was produced by control sample with 31.00 MPa and 42.16 MPa for 7 and 28 days of curing, respectively. From the **Table 3**, it can be concluded that all the sample either 7 days or 28 days has successfully achieved the desire strength as design in the range of mix design which is 30 MPa.

Table 3: The average compressive strength and different percentage of curing days

Sample mixed	MSF Volume Faction (%)	Compressive Strength of Concrete (MPa)		Different percentage of curing days (%)
		7days	28 days	
Controlled	0	31.00	42.16	26.5
0.50% MSF	0.50	3.21	46.38	26.2
0.75% MSF	0.75	42.88	50.21	14.6
1.00% MSF	1.00	47.71	59.21	19.4
1.25% MSF	1.25	52.81	64.22	17.8

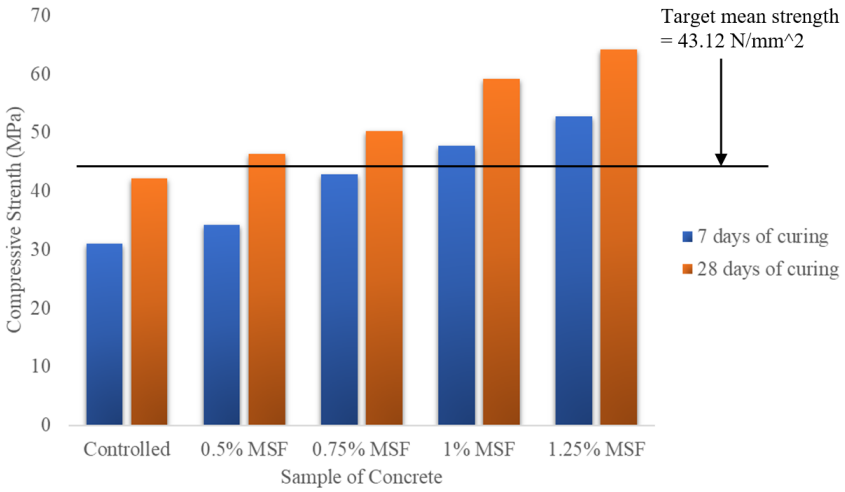

Figure 3: Compressive Strength vs Sample of Concrete

From the **Figure 3**, the compressive strength of sample containing Micro Steel Fiber exceed the target mean strength of 43.12 MPa as in the range of mix design at 28 days. In addition, the Figure 3 also shows that the sample containing highest percentage of Micro Steel Fibre which is 1.25% achieved the desire target mean strength as early as 7 days of curing. It may also be stated that incorporating Micro Steel Fiber into the compressive strength development process was proved successful.

3.4 Relationship between Density and Compressive Strength

The **Figure 4** shows that the relationship between density and compressive strength of the concrete sample. The **Figure 4** shows that when the density is increase, the compressive strength also increases. For example, sample containing 1.00% of Micro Steel Fiber provide the density of 23.90 and compressive strength 47.71 MPa. When the percentage of Micro Steel Fiber added to 1.25% of Micro Steel Fiber, the density has significantly increase to 23.97 or 0.3%, while the compressive strength increased to 52.81 MPa or 10% for 7 days of curing period.

Meanwhile for samples day 28 that containing 0.50% of Micro Steel Fiber provide the density of 23.70 and compressive strength 46.38 MPa. When the percentage of Micro Steel Fiber added to 0.75% of Micro Steel Fiber, the density has significantly increase to 23.87 or 0.7%, while the compressive strength increased to 50.11 MPa or 8%.

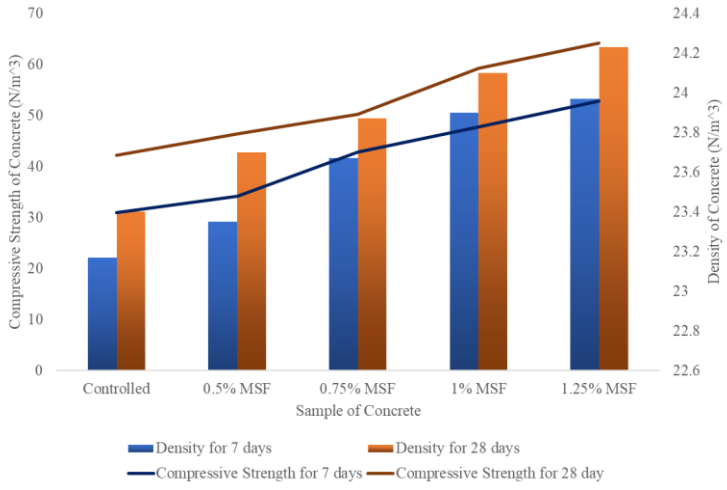

Figure 4: Relationship between Density and Compressive Strength

4. Conclusion

In conclusion, the density value for each sample with a different percentage of Micro Steel Fiber were different which is the sample with the highest percentage of Micro Steel Fiber that is 1.25% is the sample with the highest density. Thus, the increment of Micro Steel Fiber, increased the compressive strength of the concrete. All workability values obtained from the slump test are still within the specified range. From the results, The varieties of workability that were discovered included moderately useable concrete, which is utilized in the most of infrastructure projects. The higher the percentage of Micro Steel Fiber in the concrete, the higher the workability value of the concrete. As a result, it is suggested decrease the proportion of the Micro Steel Fiber due to the high cost of Micro Steel Fibre and the outcome indicates a good increase in its strength.

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References

[1] P. Zhang, J. Wan, K. Wang, And Q. Li, "Influence of Nano-Sio2 on Properties of Fresh and Hardened High Performance Concrete: A State-of-The-Art Review", Construction and Building Materials, vol. 148, pp. 648–658, 2017. doi: 10.1016/j.conbuildmat.2017.05.059. [Online]. Available: https://doi.org/10.1016/j.conbuildmat.2017.05.059. [Accessed Nov. 24, 2020]

[2] P. Zhang, Y.-N. Zhao, Q.-F. Li, T.-H. Zhang, And P. Wang, "Mechanical Properties of Fly Ash Concrete Composites Reinforced with Nano-Sio2 and Steel Fiber", Current Science, vol. 106, no. 11, pp. 1529–1537, 2014. [Online]. Available: https://www.researchgate.net/publication/264708185_Mechanical_properties_of_fly_ash_concrete_composite_reinforced_with_nano-SiO2_and_steel_fibre. [Accessed Nov. 24, 2020]

[3] Iqrar Hussain, Babar Ali, Tauqeer Akhtar, Muhammad Sohail Jameel, Syed Safdar Raza. "Comparison of mechanical properties of concrete and design thickness of pavement with different types of fiber-reinforcements (steel, glass, and polypropylene)", Case Studies in Construction Materials, vol. 13, December 2020. [Online]. Available: https://doi.org/10.1016/j.cscm.2020.e00429. [Accessed Jan. 2, 2021]

[4] Fatih Altun, Tefaruk Haktanir, Kamura Ari. Effects of steel fiber addition on mechanical properties ofconcrete and RC beams. Construction and Building Materials, vol. 21, pp. 654–661, 2017.

[5] Norhayati Ngadiman, Mardiha Mokhtar, Noorul Hudai Abbdullah, Amir Khan Suwandi, Mohd Erwan Sanik, 2019. DAC11503 Civil Engineering Materials, UTHM Publisher, vol. 2019.

[6] A.M. Neville, Concrete Technology, Vol. 2, Pp. 94–120, 1994.